1,026,768

PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Multitextural Metallic Strip

We, REYNOLDS METALS COMPANY, a Corporation of the State of Delaware, United States of America, of 6601 West Broad Street, Henrico County, Richmond Post Office, Virginia, United States of America, de hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to multitextural metallic articles having a plurality of constituents and exhibiting novel properties. The invention further concerns multi-alloy aluminous metal articles, produced from mixtures of different aluminous metal particles, and having unusual ornamental and decorative surface characteristics.

This invention is a modification of the invention of Patent No. 893,171. In the prior patent, there was disclosed a methed of making a solid strip of aluminous metal, comprising the steps of preheating particles of aluminous metal to a temperature in the range from 450°F. to 1200°F., the particles being free-flowing at the preheat temperature, and then rolling the particles at substantially the preheat temperature under pressure between a pair of rolls to form a fully densified strip. The aluminous metal particles employed for that purpose could be either spheroidal or acicular in shape, but should all be above 200 mesh size. The resulting strip could be further work-hardened, heat treated, or anodized.

It has now been found that the basic methods disclosed in the prior application can also be applied to the direct rolling of mixtures of particles of two or more different metals at least one of which is an aluminum alloy to form self-supporting multi-alloy flat stock.

According to the invention, therefore, a method of making solid metallic strip comprises preheating a particulate mixture of at least two different materials including particles of aluminous metal to a temperature not less than 450°F but below the incipient melting point of the particles of the mixture, the said aluminous metal particles being enclosed by a surface layer of oxide, feeding the preheated particles in free-flowing condition to a set of work rolls and rolling the particles at substantially the preheat temperature under pressure between the said rolls to form a fully densified and self-supporting strip.

Where the particulate mixture consists of particles of different aluminous metals, the temperature range quoted in the main patent, namely 450°F-1200°F, holds good.

According to another aspect of the present invention, similar aluminous metal articles may be produced which incorporate various non-metallic or non-aluminous metal constituents. There can be employed, for example, in admixture with aluminous metal particles, materials such as graphite, alumina, inorganic pigments, irridescent substances and glass fiber, in order to obtain novel properties and striking decorative effects.

By means of the instant teaching, furthermore, it is possible to produce a composite clad sheet, one side of which exhibits variegated ornamental effects, while at the same time the composite exhibits other desirable characteristics attributable to the backing substance. The cladding is accomplished by applying the particle mixtures to the backing layer (preferably metallic) at a point just preceding the entrance of the backing layer into the nip of the rolls. The preheat temperature for the particles must be below the meltingtemperature of the backing metal, or of any eutectic alloy which might be formed between the cladding particles and the backing metal. In general, the temperature will exceed 450°F., and a recirculating furnace may be used to heat the material to the desired temperature.

Articles produced according to the inven-

tion are particularly siutable for various surface finishing techniques, which may be advantageously employed to accentuate the appearance of various constituents. Contrasting effects may be obtained by polishing or etching of the surface. Furthermore, other techniques such as embossing may be applied to achieve mechanical indentations and surface irregularities, and to achieve variations in tone. Other differential visual effects may be produced by various chemical or electrolytic techniques, such as anodizing, particularly when supplemented by a coloring system. The presence in the aluminous metal of impurities and alloying elements, such as silicon, iron, copper, manganese, magnesium, zinc and chromium, directly affect the response of the material to such finishing operations. Thus, in the case of additions of silicon in the range of 2% to 8%, a gray tone is imparted to the anodized surface. Oxidation products of manganese and chromium appear as yellow to brown coloured tints.

An article produced in accordance with the invention has unique characteristics and properties, since the composition is not necessarily homogeneous. It is possible, therefore, to randomly dispose various minor constituents in a principal matrix of aluminous metal. It can be seen, therefore, that a limitless array of variegated effects, striations, simulated wood grains, and many other decorative effects are obtainable.

The invention is applicable to any suitable aluminous metals or aluminium alloys including, for example, but not limited to, the (American) Aluminum Federation specification Alloys 1100, 3003, 4543, 5052, 6061, 6063, and 7075, and various combinations thereof. The term "aluminous metal" is employed herein with reference to aluminum and aluminum base alloys containing at least 51% of aluminum.

For a better understanding of the invention and its various objects, advantages and details, reference will be made to present preferred embodiments thereof which are shown, for purposes of illustration only, in the accompanying drawings. In the drawings:

Fig. 1 is a diagrammatic view of apparatus for preheating and rolling mixtures of particles into solid aluminous metal strip;

Fig. 2 is a corresponding view of a modified species of the apparatus shown in Fig. 1;

Fig. 3 is a photographic view perpendicular to the surface of a sheet produced in accordance with Example 5.

Referring now to the drawings, and initially to Fig. 1, the illustrated apparatus 10*a* receives aluminous centrifugally cast particles 11 in a hopper 12, which feeds them to a pair of work rolls 14 and 15. These rolls have a nip 16 through which the particles 11 are fed and rolled under high pressure to consolidate them into a solid metal strip 18. The strip forming rolls 14 and 15 are driven at equal peripheral speeds by any suitable means (not shown). Although not essential, it is preferable to pass the fully densified strip 18 through one or more subsequent pairs of work rolls 20 to work the metal and reduce it to gauge, without sintering at any stage. The subsequent rolling may be carried out by conventional practices as to temperatures and other conditions (including any desired annealing) suitable for the particular metal and the desired final gauge and properties, such as temper.

The particles 11 are preheated by any suitable means before they are fed into the hopper 12, or they may be heated while in the hopper. What is important is the temperature of the particles 11 as they are fed into the work rolls 14 and 15. A pair of sprayers 19 are located on the side of the rolls 14 and 15 near the emerging sheet 18, and direct a stream of coolant against the rolls 14 and 15.

In the variant form of apparatus 10b shown in Fig. 2, the particles 11 are fed from a feed hopper 30 onto a moving belt 32 which passes them through a discharge point 34. The moving belt 32 and the feed hopper outlet 36 are enclosed in a heating furnace chamber 38. Hot air 40 is fed through one or more inlet ducts 42, to heat the particles on the moving belt 32, and the exhaust air 41 is withdrawn through one or more outlet ducts 44. The heated particles are discharched into a second hopper 46, and thence are passed into the nip of compacting rolls 14 and 15 corresponding to those described above in connection with Fig. 1.

In accordance with the invention, a mixture of particles of different composition are introduced between the rolls 14 and 15. Moreover, a backing strip can be fed between the rolls 14 and 15 with the particles, such as one strip against either of the rolls 14 or 15 for purposes of forming a cladding layer thereon or one or more strips can be fed through the rolls with the particles on both sides thereof so that such strip or strips would be covered on both sides by a layer of solid metal formed from the particles.

The following example is illustrative of the principles of the method as described in Specification No. 893,171.

A charge of molten aluminous metal containing at least 99% aluminum was held in the melting furnace and discharged into a hollow cylindrical casting pot made of cast iron, having an outside diameter of 3 inches, and having 0.052 inch diameter openings through its side wall on 3/8 inch centers and arranged in ten rows. The pot was rotated about its vertically-disposed central axis at about 3943 r.p.m. and molten aluminum was fed into its open top at a temperature in the pot of 1345°F. The particles cast from the pot were acicular in shape, and have the fol-

lowing representative U.S. Standard screen analysis:

Held on 10 mesh	Trace
Through 10, held on 20 mesh	20.1%
Through 20, held on 30 mesh	41.9%
Through 30, held on 40 mesh	26.8%
Through 40, held on 50 mesh	9.8%
Through 50, held on 60 mesh	1.1%
Through 60 mesh	.3%

These acicular particles were preheated to a temperature of about 900°F. in an air furnace equipped with a circulating fan and heated by electrical resistance heaters. The heated acicular particles were immediately transferred to a hopper leading to a pair of compacting rolls having their axes lying in a common horizontal plane. The rolls were 6 inches in diameter, with a 7 inch face, and had an initial roll gap setting of 0.052 inches. During rolling, the rolls produced a calculated pressure of about 12,000 p.s.i. on the particles. The particles flowed freely from the hopper into the roll nip, and were compacted by the rolls into a strip 7 inches wide and 0.098 inch thick, and having a density of 2.71 grams per cubic centimeter. The strip speed was 54 feet per minute, and at that speed the strip was well formed and strong and needed relatively little trimming along the edges to elminate incompletely rolled areas.

The as-rolled strip had a fibrous character resulting from the broken-up remains of the oxide walls of the original particles. Tests showed a tensile strength of 20,916 p.s.i. (ultimate) and 18,300 p.s.i. (yield) with an elongation of 14% (based upon a 2-inch gage length). After being given sufficient cold-rolled reduction (e.g. 83% and 94%) to permit full recrystallization upon being annealed at 600°F., the strip was found to have strength and elongation characteristics corresponding to those of strip of 99% aluminum (1100 Alloy) produced by rolling down large ingots in accordance with conventional mill practice (based on the figures reported in American Society for Metals Handbook, 1948 edition, page 771, Table 1).

The following Examples illustrate the present invention.

Example 1

Aluminous particles of 6061 alloy and 7075 alloy were produced as described in the foregoing example, both alloy particles having a particle size range of substantially 20 to 60 mesh and being of acicular shape. The particles were mixed thoroughly in the proportion of 80% by weight 6061 alloy and 20% 7075 alloy. This mixture was preheated to a temperature of about 800°F. and rolled described in the foregoing example using a gap setting of 0.015 inches, and rolled in a single pass to a strip of 0.045 inch thickness. The rolled strip was subjected to a finishing sequence including degreasing in a non-etching detergent, rinsing with tap water, etching in 6 oz. per gallon sodium hydroxide solution at 140°F. for 10 minutes, rinsing again with tap water, and then anodizing in 15% by weight sulfuric acid solution at 70°F. employing an average current density of 15 amperes per sq. ft. for 30 minutes. The anodized strip was rinsed with tap water, and the anodized coat sealed with boling distilled water for 10 minutes.

The resulting surface finish showed dark, roughly etched areas of 7075 intermixed with bright areas of 6061. After conventional dyeing of this surface with a blue organic dyestuff, a more subdued contrast was produced showing dark and light blue areas for the respective constituents.

Alloys 6061 and 7075 exhibit vastly different electrochemical behavior. Of the various intermetallic compounds present, $CuAl_2$ and Beta Al-Mg are oxidized or dissolved much more rapidly than aluminum. Others, such as $MnAl_6$ and $FeAl_3$ oxidize with the aluminum, whereas Al_3Zn_2 is partially oxidized and dissolved. Finally, the compounds Mg_2-$Si_2Al_3Mg_2$ and $Al_2Mg_3Zn_3$ are virtually totally dissolved during anodizing.

When the two materials 6061 and 7075 are individually etched and anodized, it can be seen that the 6061 surfaces have a response to bright finishing comprable to pure aluminum, whereas the 7075 is more susceptible to the dissolving action of the anodizing bath. The anodic film of 6061 is quite clear, with etching prior to anodization showing a levelling action with little or no dark smut produced, while etching of 7075

produces a roughening effect on the surface which results in darkening of the anodic film and a near black appearance. In addition, the variation in electrolytic potential results in more oxide being formed on hte 7075 alloy.

Example 2

Following the procedure of Example 1, a mixture was prepared of acicular particles of 10% by weight of alloy 7075, and of 90% by weight of alloy 1100, having the nominal composition:

Si and Fe	1.0% max.
Cu	0.20% max.
Mn	0.05% max.
Zn	0.10% max.
Al	99.0% max.

This mixture was made into a sheet as before, and then cleaned, rinsed and anodized as in Example 1. Following the anodic treatment, the areas of 1100 alloy showed considerable brightness and luster, whereas the alloy 7075 areas gave a dark contrasting appearance.

Example 3

A blend was formed of 16% by weight of acicular particles of alloy 4543 having a mesh size between 10 and 60 mesh (predominantly 10 to 30 mesh) and 84% by weight of spheroidal particles of alloy 100 having a size from 10 to 20 mesh. The mixture was heated to 900°F. in air, poured into the nip of rolls with a roll gap setting of 0.015", and rolled in a single pass to a sheet of 0.045" thickness having a variegated appearance. Immediately after rolling, without further treatment, the presence of the alloy in minor proportion could be observed (see Fig. 3) by reflected light.

Similarly to Examples 1-3, sheets were prepared by rolling various mixtures of alloys, as shown in Table 1. In the formation of sheets from the alloy particles indicated in Table 1, the particles of aluminous metal were of acicular shape, and in a size range of 10 to 60 mesh, unless otherwise noted. The stated percentages are by weight, and the usual preheating temperature was 900°F. (exceptions noted).

Table I

Alloy A	%	Alloy B	%		Alloy C	%
1100	5	3003	95			
1100	15	3003	85			
1100	95	3003	5			
1100	95	7075	5			
1100	50	7075	50			
1100*	84	4543	16			
1100*	84	4543*	16			
1100	16	4543*	84			
1100	50	6061	50			
1100	80	6061	20			
6061	50	7075	50	(See Note 1)		
1100	80	7075	20	(See Note 1)		
1100	80	5052	20			
6061	90	7075	5		5052	5
1100	80	7075	10		5052	10

*spheroidal (substantially 5 to 10 mesh).
Note 1 preheated at about 800°F.

Example 4

Acicular particles of 1100 alloy predominantly 10 to 40 mesh size were combined with 0.5% by weight of fiberglass in the form of 1/4-1/2 inch long fibers. The composite mixture was preheated to about 950°F. and rolled in a manner similar to that of Example 3 to produce a solid sheet having the fibers integrally dispersed therein.

Likewise, a composite strip was formed from 6061 alloy particles, having blended therein 5% by volume of graphite particles. Both the aluminous metal and the graphite particles were in the size range 10 to 60 mesh, and the metal particles were acicular in shape.

Example 1-4 are indicative that virtually innumerable multi-alloy combinations of aluminous metal particles, with or without additional non-metallic and non-aluminous metal materials, may be compacted to produce articles having unusual properties and ornamental features. The contrasting visual effects thereby achieved may be emphasized by means of conventional finishing techniques, such as polishing etching, and anodizing.

Furthermore, the ultimate characteristics of such an article may be varied by appropriate choice of particles (as to shape and composition, as well as size within the stated board range), and the subsequent working procedures employed. For example, the visible patterns in flat stock have a natural tendency to elongate in the direction of the initial rolling operation. To counteract that effect, the sheet may be subsequently cross-rolled to achieve a more uniform distribution of the ingredients.

WHAT WE CLAIM IS:

1. The method of making solid metallic strip which comprises preheating a particulate mixture of at least two different materials including particles of aluminous metal to a temperature not less than 450°F but below the incipient melting point of the particles of the mixture, the said aluminous metal particles being enclosed by a surface layer of oxide, feeding the preheated particles in free-flowing condition to a set of work rolls and rolling the particles at substantially the preheat temperature under pressure between the said rolls to form a fully densified and self-supporting strip.

2. The method of Claim 1 in which the particulate mixture comprises particles of different aluminous metals.

3. The method of Claim 1 in which the particulate mixture includes non-metallic particles.

4. The method of any of Claims 1 to 3 for producing a strip of metal having a variegated surface appearance in which the particulate mixture includes (a) cast particles of aluminous metal substantially all of which are coarser than 200 mesh size and (b) particles composed of different material which is compatible with the said aluminous metal particles for rolling purposes.

5. The method of claim 4, including a finishing step to intensify the visual distinction between the regions of different composition at the surfae of the strip.

6. The method of claim 4 or 5 in which particles of two different aluminous metals are mixed together, and the resulting particulate mixture is heated to a temperature in the range of 450° to 1200°F at which the particles are free-flowing.

7. The method of Claim 6 in which the rolled strip is etched and anodized to intensify a visual distinction between the regions of different composition.

8. The method of making a solid metallic strip substantially as described in any of Examples 1-4 herein.

9. A solid metallic strip made by the method of any of the preceding claims.

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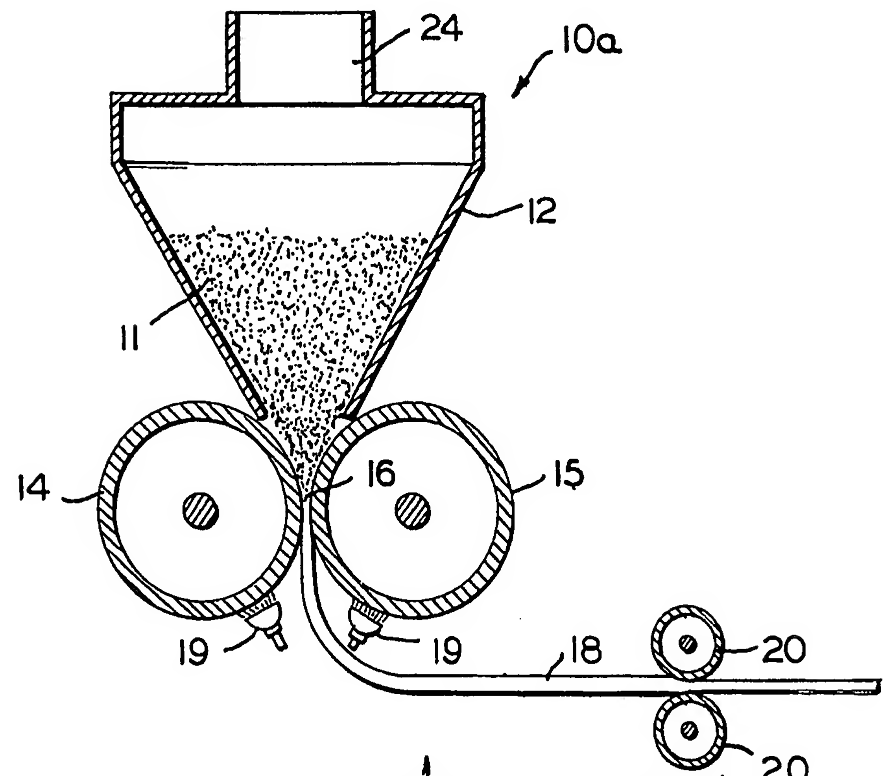
FIG 1.



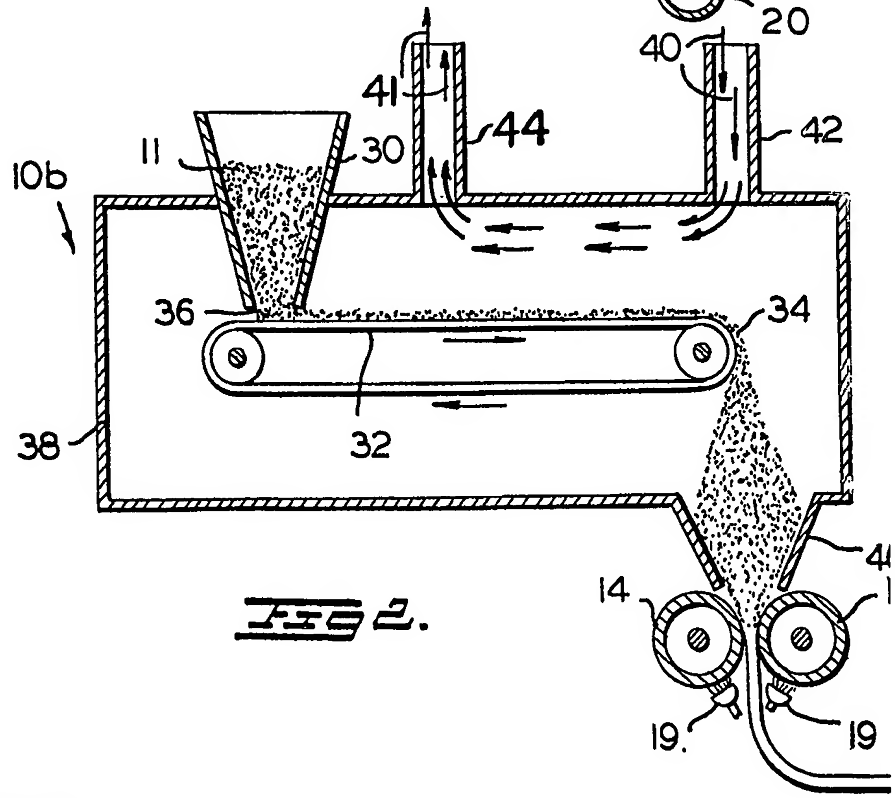


FIG 2.

D 61040/1/109 175 2/66 TCL

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2 SHEETS

This drawing is a reproduction of the Original on a reduced scale.

SHEETS 1 & 2

Fig. 3

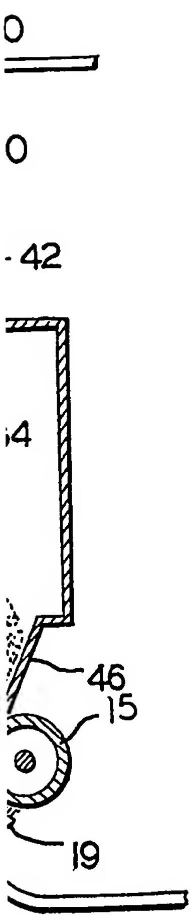
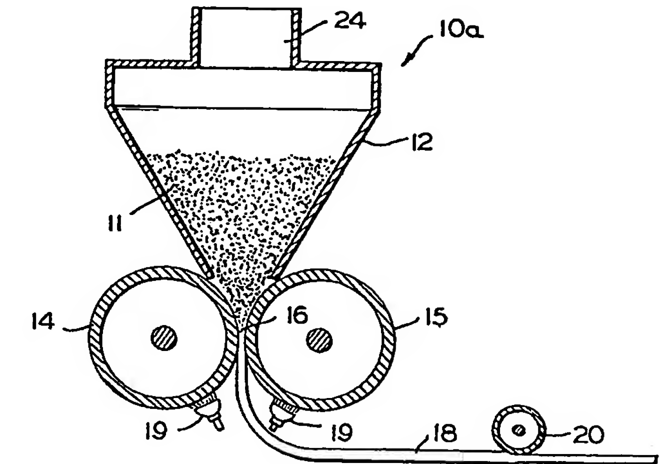


FIG. 1.



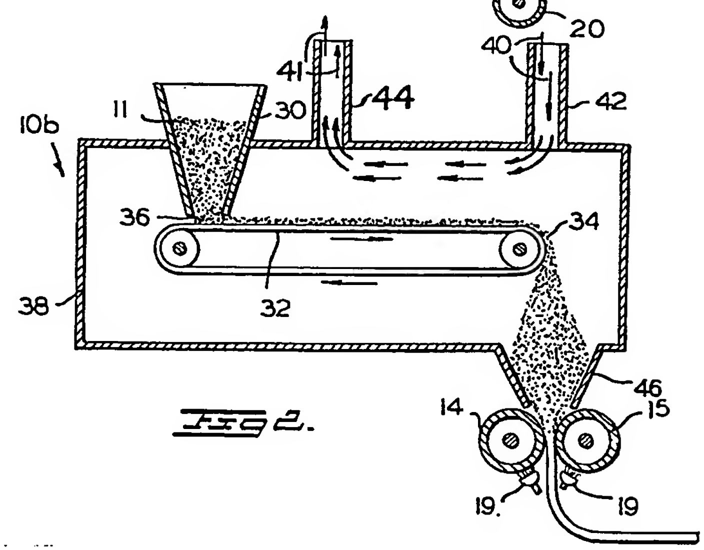


FIG. 2.

FIG. 3